SURVIVAL, SEASONAL MOVEMENTS, AND COVER USE BY LESSER PRAIRIE CHICKENS IN THE TEXAS PANHANDLE

A Thesis

by

BENJAMIN EDWIN TOOLE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2005

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

Chair of Committee,	Nova J. Silvy
Committee Members,	Markus J. Peterson
	Fred E. Smeins
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ABSTRACT

Survival, Seasonal Movements, and Cover Use by Lesser Prairie Chickens in the Texas Panhandle. (August 2005)

Benjamin Edwin Toole, B.S.; B.S., Texas A&M University

Chair of Advisory Committee: Dr. Nova J. Silvy

Lesser prairie chicken (*Tympanuchus pallidicinctus*; LPC) numbers have declined considerably in Texas since the early 1900s. As with other prairie chicken species, reasons for declining ranges and numbers have been attributed primarily to degradation and fragmentation of habitats. Until my study, no telemetry-based research on LPC has been conducted in the Rolling Plains of the Texas Panhandle. I radio-tagged and monitored LPCs in 2001 (spring–winter) and 2002 (spring) at a stable population in a native rangeland landscape (Study Area I) and in a declining population in a fragmented rangeland and agricultural landscape (Study Area II).

No significant ($P < 0.05$) differences in survival were detected for combined study areas between years, or between study areas within years. Ranges and movements, as independent criteria by season, sex, and age classes combined were similar ($P > 0.05$) for both study areas.

Lesser prairie chickens predominately occupied native rangeland cover types (>85%) compared to non-native rangelands at both study areas. Total invertebrate dry mass for all orders differed between native rangeland and Conservation Reserve

Program (CRP) sites at Study Area II. Over 32 times more dry mass of invertebrates was collected at the native rangeland site than were collected at the CRP site.

Herbaceous cover differed significantly for grasses ($P < 0.01$), forbs ($P < 0.01$), and bare ground ($P < 0.01$), but not for litter ($P = 0.43$) or woody cover ($P = 0.63$) between study areas. The similar range sizes, movement distances, and cover use observed for both study areas may provide insight into minimum area requirements for LPCs within the Rolling Plains in the Texas Panhandle.

DEDICATION

To my parents

ACKNOWLEDGMENTS

I would like to sincerely thank my committee chair, Dr. Nova J. Silvy, and my committee members, Dr. Markus Peterson and Dr. Fred Smeins, for their assistance and patience throughout this study. I would especially like to thank Dr. Silvy for this opportunity and his constant support and friendship.

I also appreciate the help of Ryan Jones for all of those hours in the field and all those mornings that came way too early. Additional thanks go to Nils Peterson and Dustin Jones for showing me the ropes in the beginning when I knew so little.

To Lance, LaVaun, Merle, and Robin, thanks for being there and for being such true friends.

Finally to Megan, thank you for all of your help, support, hours of listening to me complain and your love.

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INTRODUCTION

Since the late 1800s, range size and numbers of lesser prairie chicken (*Typmanuchus pallidicinctus*; LPC) have decreased considerably in historically occupied regions of eastern New Mexico, southeastern Colorado, southwestern Kansas, western Oklahoma, and the Texas Panhandle (Crawford 1980, Taylor and Guthery 1980). Range-wide declines in numbers (>97%) were believed to have resulted primarily from habitat loss (Crawford 1980, Taylor and Guthery 1980, Pittman 2003). Jones (1964) also noted that invertebrates, particularly the order Orthoptera, were important to LPC during summer and fall months. Orthoptera are especially beneficial to the growth and development of chicks (Griffon et al. 1997). Griffon et al. (1997) noted that insufficient invertebrate abundance could limit prairie chicken brood survival, and thus chicken numbers.

Earlier prairie chicken researchers, such as Lehman (1941), Hamerstrom et al. (1957), and Jackson and DeArment (1963), were already observing the final decline in prairie chicken abundance. These birds have continued to decline in their ranges and populations over the past 50 years.

Litton (1978) estimated up to 2 million LPC were in Texas prior to 1900. By 1974, estimated numbers had declined to about 17,000 (Litton 1978). Concerns of extinction in Texas initially arose in the 1930s, when population levels were restricted to portions of 12 counties (Sullivan et al. 2000). Though numbers of LPC in Texas

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increased to huntable levels in the 1960s, abundance again declined in the 1990s due to drought and continued habitat loss (Sullivan et al. 2001). In 1940, LPC inhabited portions of 20 counties (1,366,578 ha), in the Texas Panhandle, but by 1989 occupied range had decreased by 58% (573,230 ha) and LPC reached record lows, thus a ban on hunting was enforced from 1937 until 1967 (Litton 1978). In 1995, the U.S. Fish and Wildlife Service was petitioned to list the LPC as threatened under the Endangered Species Act, and in 1998 a "warranted but precluded" listing was given (Federal Register 1998).

Previous research on LPC in Texas has occurred primarily in the shinnery oak (*Quercus harvardii*) rangelands of the southwestern Texas Panhandle (e.g., Crawford and Bolen 1976, Haukos and Smith 1989, Haukos et al. 1990, Olawsky and Smith 1991). No telemetry-based studies have been conducted in the Rolling Plains region of the Texas Panhandle. However, from 1940 through the 1960s, Jackson and DeArment (1963) evaluated ranges, movements, and breeding success in Hemphill and Wheeler Counties through general observation.

In 2001, Texas A&M University, in association with Texas Parks and Wildlife Department (TPWD), initiated a 3-year study of LPC in the northeastern Texas Panhandle in portions of Lipscomb, Hemphill, and Wheeler Counties. Field activities began during April 2001 and concluded August 2002. The objectives of this study were to determine LPC (1) breeding-season survival, (2) seasonal ranges and movements, (3) cover use, (4) invertebrate abundance during the brood-rearing season, and (5) micro-habitat analysis of winter vegetation.

STUDY AREAS

Field research was conducted in the northeastern portion of the Rolling Plains ecoregion (Gould 1962) of the Texas Panhandle (Fig. 1) in portions of Lipscomb, Hemphill, and Wheeler Counties. The Rolling Plains has an elevation ranging from 242–909 m (Gould 1962). The average annual temperature was 16.9 C, and the average annual rainfall was 55.7 cm (Gould 1962).

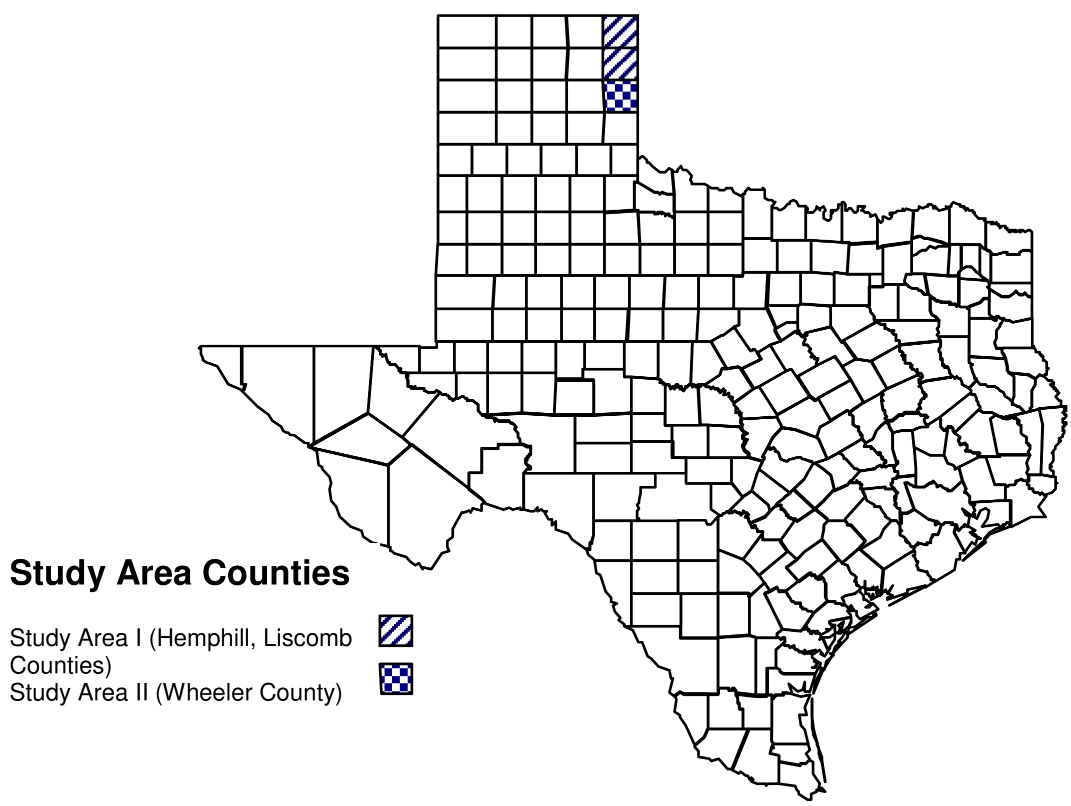

Fig. 1. Counties in the Rolling Plains of Texas where study areas were located, 2001–2002.

In 2001, study areas were located in portions of Hemphill (Study Area I) and Wheeler (Study Area II) Counties. In 2002, Study Area I was expanded to include the southern portion of Lipscomb County, Texas. Primary land uses at both study areas were ranching and natural gas extraction. Both study areas were located in native rangelands with different woody species but contained similar grass and forb associations as described by Jackson and DeArment (1963). The primary land uses at both study areas were ranching and natural gas extraction.

Topography of the 2 study areas varied from flat to gently rolling with some upland dunes and stabilized hummocks. Study Area I consisted of 2 soil associations: Tivoli-Springer and Dalhart-Dumas-Springer. The Tivoli-Springer association, the most prevalent, contained deep, loose, sandy soils on upland dunes and hummocks (Jackson and DeArment 1963). The Dalhart-Dumas-Springer association contained deep, loamy level-sloping soils on uplands. Study Area II consisted of 4 soil associations: Pratt-Delwin, Grandfield-Devol, Devol-Tivoli, and Grandfield-Hardeman (Jackson and DeArment 1963). The Pratt-Delwin association was the most prevalent and contained deep to shallow, gently sloping, and rolling silt loams. The Grandfield-Devol association contained deep, nearly level-gently sloping loamy fine sands. The Devol-Tivoli association contained deep, gently sloping-steep loamy fine sands. The Grandfield-Hardeman association contained deep, nearly level-sloping fine sandy loams.

Study Area I was dominated by sand sage (*Artemisia filifolia*), with lesser amounts of Chickasaw plum (*Prunus angustifolia*) and fragrant sumac (*Rhus aromatica*), whereas Study Area II was dominated by shinnery oak. Dominant grass species on both study areas included little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardi*), switchgrass (*Panicum virgatum*), Indian grass (*Sorghastrum nutans*), sand lovegrass (*Eragrostis tichodes*), sand dropseed (*Sporobolus cryptandrus*), fringeleaf paspalum (*Paspalum ciliatifolium*). Areas of tighter soils supported buffalograss (*Buchloe dactyloides*) and blue grama (*Bouteloua gracilis*). Common forbs included camphorweed (*Heterotheca pilosa*),Texas croton (*Croton texensis*), western ragweed (*Ambrosia psilostachya*), and queensdelight (*Stillingia sylvatica*).

Study Area I consisted of 3 ranches totaling 13,553 ha in portion of Hemphill and Lipscomb Counties, Texas. Native grass pasture ranching was the dominant agricultural land use in this study area. All properties in Study Area I consisted of little-bluestem, sand sage-dominated rangelands, with lesser amounts of fragrant sumac and Chickasaw plum. The largest property (8,491 ha), constituted the southern portion of Study Area I and was located in Hemphill County on a private ranch, 14 km northeast of Canadian, Texas. On-site grazing pressure was moderate, though grazing pressure on adjacent properties varied from light to heavy. A limited, steer-stocker operation was used on-site. Adjacent properties used both cow-calf, and steer-stocker operations. A residential structure was located on the property. Extensive gas development and infrastructure, in the form of roads, occurred on the study area and surrounding properties. No active crop production occurred on the property or on adjacent properties.

In 2002, Study Area I was expanded by 5,061 ha to include 2 additional ranches located in Lipscomb County, Texas. One ranch (northern) was 2,308 ha in size and located 2.4 km west of Higgins, Texas. This location received moderate to heavy grazing pressure from a rotational cow-calf grazing regime. Minimal natural gas infrastructure occurred on-site and on adjoining properties. No active crop production occurred on the property, but center-pivot wheat production was located on adjoining properties to the southwest and west. The second property was 2,752 ha in size and located along the boundary of Hemphill and Lipscomb Counties approximately 7.9 km west of Higgins, Texas. On-site grazing pressure during 2002 was moderate to moderate heavy and adjacent properties were moderately grazed. A non-rotational, cow-calf operation was used on-site and on most adjoining properties. Minimal natural gas infrastructure and road development occurred on-site and on adjoining properties.

Study area II (8,129 ha) consisted of a single ranch in Wheeler County, Texas, approximately 5 km south of Allison. Since 1900, the ranch had been used for cattle production, and since the 1970s for natural gas extraction. Surrounding land use included ranching and farming operations, though farming was historically more prominent up to the 1970s. Several nearby fields were enrolled in conservation reservation program (CRP) contracts primarily planted in monoculture stands of weeping lovegrass (*Eragrostis curvula*). On-site grazing pressure was heavy, while grazing pressure on adjacent properties varied from light to heavy. A cow-calf operation was used on-site and on adjacent properties. Three active residential structures were located on the Study Area II. Extensive gas infrastructure, including roads and gas-petroleum storage tanks, occurred on the study area. Natural gas extraction was minimal on surrounding properties. No active crop production occurred on the study area or on surrounding properties. Historically, dry-land farming was prominent on most surrounding properties.

METHODS

Field activities commenced in spring 2001 and continued through summer 2002. Trapping was conducted on 6 leks (Study Area I = 4, Study Area II = 2) from 01 April–28 May 2001 and on 8 leks (Study Area I = 6, Study Area II = 2) from 01 April–01 June 2002. In 2002, the 2 additional leks trapped in Study Area I were in Lipscomb County. Lesser prairie chickens were captured with rectangular-shaped drop nets (Silvy et al. 1990). Drop nets were made of cotton or 6.5 x 6.5-cm mesh nylon fish net and could be sized to capture individual birds or cover entire display grounds. The largest net was 30.5 x 10.7 m and the smallest 9.1 x 4.6 m.

Immediately upon capture, LPC were sexed and aged. Age was determined by barring patterns on the outermost primary (Campbell 1972) and classified as juvenile (~ 10 months) or adult (≥12 months). All LPC were weighed to nearest gram with a spring scale. Numbered aluminum leg bands were attached to each bird.

Two models of necklace–style radio transmitters were used during the study. Both featured 8–hour motion–sensitive switches, and weighed approximately 12 g (<2 % body weight), with a nominal power supply of 9–12 months. Non-adjustable collar-style radio transmitters (150.000–150.999 MHz) with fixed–loop antennas (Telemetry Solutions, Walnut Creek, California) where used in 2001, while adjustable collar-style transmitters (150.00–151.999 MHz) with whip antennas (Wildlife Materials Inc., Carbondale, Illinois) were used in 2002.

Lesser prairie chickens were monitored using a 5-element, truck mounted antenna or a 3-element handheld antenna. Birds were monitored once daily (3–4 days/week), but females were monitored more intensive (5–7 days/week) during spring months to minimize loss of radio contact due to movement from study sites associated with breeding or nest-site selection. Estimated locations were calculated using ≥3 azimuths at georeferenced receiving stations (White and Garrott 1990) stored in a Global Positioning Satellite (GPS) unit. To minimize size of associated error polygons, azimuths were collected <20 minutes apart and as close to signal source as was possible (Heezen and Tester 1967).

I used the Kaplan-Meier estimator modified for staggered entry (Pollock et al. 1989) to calculate survival rates. Survival estimates were limited to the breeding seasons of 2001 and 2002 because the limited battery life of the transmitters. Birds that experienced radio failure or could not be located were censored and removed from further analysis. To compare survival estimates between study areas, data for each study area were pooled across years. I assessed differences among survival curves using the long-rank test (Pollock et al. 1989).

To investigate seasonal range sizes and daily movements, telemetry data were recorded as either within breeding (April–September), fall (October–December), and winter (January–March). A minimum of 15 locations per bird were required to estimate ranges (N. J. Silvy, Texas A&M University, personal communication), and a minimum of 5 locations per LPC were used to estimate mean movements between locations. Seasonal ranges were calculated using Mohr's 95% minimum convex polygon (Mohr 1947). Estimated X and Y locations were generated with Location of a Signal software (LOAS™) and entered by bird and date into an ArcView™ Animal Movement extension (Hooge and Eichenlaub 1997) for range and movement analysis. Movements and ranges were non-normally distributed, so seasonal ranges and movements were rank transformed and analyzed with Analysis of Variance (ANOVA) using a General Linear Model (GLM) to determine if significant ($P \leq 0.05$) differences in seasonal ranges could be delineated.

Cover-type use was evaluated with convex polygons drawn around the outer perimeter of all telemetry locations for LPCs trapped from an individual lek. Polygons were then overlayed upon black and white Digitial Ortho Quadrangle (DOQ) images viewed in ArcView to estimate habitat selection. When polygons of separate leks overlapped, they were combined into a contiguous use polygon. Within each polygon, general cover classes (native rangeland, non-native rangeland, cropland, or urban) were identified and their areas (ha) calculated. To assess cover types not selected, but available, a 2,000-m-buffered area (non-use polygon) outside each independent- or contiguous-use polygon was generated. Cover types and areas within the non-use polygons were then identified, calculated, and compared to cover types within use polygons.

Invertebrate abundance analysis during a brood-rearing season was conducted in summer 2002 for Study Area II to compare invertebrate abundance in native prairie to a CRP site. Descriptive statistics (means and standard errors [SE]) were used to describe invertebrate frequency and mass between a monoculture CRP site and a native rangeland site. Two sample *t*-tests ($P \leq 0.05$) were used to determine significance of total dry invertebrate masses between native rangeland and CRP sites.

Winter vegetation analysis was conducted during winter (December 2001–February 2002). Visual obstruction measurements were collected at 159 (Study Area I, n = 55; Study Area II, n = 104) random locations within a 1.4-km radius of the known largest lek located within each study area. A range pole (Robel et al. 1970), demarked at 10-cm (1-dm) intervals, was used to estimated obstruction of vision (OV) cover related to woody, grass, and forb classes. Four OV measurements at cardinal directions (0^0, 90^0, 180^0, 270^0) were recorded at each plot (Robel et al. 1970). A mean OV measurement for each study area was calculated and analyzed with 2 sample t-tests to determine if significance ($P \leq 0.05$) difference existed between study areas.

To investigate woody species distribution between study areas, 8-m^2 quadrats were centered at each visual obstruction location to estimate woody stem frequency. A χ^2 analysis was used to determine if woody occurrence differed between study areas. Percent herbaceous coverage (within 5% increments) was estimated at 153 (Study Area I, n = 55; Study Area II, n = 98) plots collected with 100-cm^2 quadrats collected in conjunction with visual obstruction measurements. At each plot, 4 measurements were collected at each cardinal direction in coordination with visual obstruction measurements. A χ^2 analysis was conducted to determine if herbaceous cover frequencies differed between study areas.

RESULTS

Fifty-five LPC were trapped at Study Area I, and 30 were trapped at Study Area II during both years of study. In 2001, 38 transmitters were placed on LPC, and in 2002, 31 transmitters were placed on LPC. No birds were monitored >9 months post-capture because of death, lost transmitters, radio failure, or emigration from the study areas. In 2001, 24 (63%) of the 38 transmitters were recovered (15 slipped off, 9 lost to predation). Fourteen LPC retained radio collars until they either emigrated from the study area, or experienced radio failure. In 2002, 12 (39%) of the 31 transmitters were recovered before this portion of the study ended on 31 August 2002. Of these, 2 appear to have slipped off, and 10 birds were lost to predation. One bird either left the study area or experienced radio failure, while 18 were alive at the end of the study.

Survival

In 2001, survival for male and female LPCs during the breeding season was 59.4 and 69.4% at Study Areas I and II, respectively (Table 1). Survival during the reproductive season in 2002 was 65.7% at Study Area I and 73.0% at Study Area II. Survival for LPCs at Study Areas I and II for the combined breeding seasons was 62.7 and 70.5%, respectively. No significant ($P > 0.05$) differences in survival were detected for combined study areas between years or study areas within years (Table 1).

Ranges

In 2001, ranges were determined for 24 birds during the breeding season and 7 birds in the fall for both study areas (Table 2). Because of transmitter failures in winter 2001, only 1 bird was sufficiently monitored to evaluate range size. During the 2002

Table 1. Breeding season survival (% ± SE) of LPC on 2 study areas in the Texas Panhandle from April–August 2001 and April–August 2002.

	Study Area I			Study Area II			Study areas combined		
Year	*n*	%	SE	*N*	%	SE	*n*	%	SE
2001	24	59.4	15	16	69.4	15	40	67.3	9
2002	23	65.7	10	8	73.0	16	31	67.5	9
Pooled	47	62.7	9	24	70.5	11	71	66.0	6

breeding season, ranges for 24 birds were determined. No additional seasons in 2002 were monitored because of termination of the study at the end of the breeding season. In 2001, 20 seasonal ranges ($\bar{x}$ = 289 ha) were determined for 16 LPCs at Study Area I, and 11 ranges ($\bar{x}$ = 178 ha) were determined for 8 LPC at Study Area II (Table 2.). In 2002, breeding season ranges (Table 1) were calculated for 17 LPCs at Study Area I ($\bar{x}$ = 167 ha) and 7 at Study Area II ($\bar{x}$ = 116 ha). Individual seasonal ranges varied from 23 ha for a male at Study Area I in the 2002 breeding season, to a high of 1,022 ha for a female at Study Area I in the 2001 breeding season.

Within Study Area I during 2001, no differences (P = 0.53) were observed in range sizes for the breeding (n = 16) and fall (n = 4) seasons (Table 2). No differences (P = 0.12) in ranges sizes were detected at Study Area I between the 2001 and the 2002 breeding seasons (n = 17). At Study Area II, range sizes did not differ (P = 0.71) between the 2001 breeding (n = 8) and fall (n = 3) seasons or between 2001 and 2002 (n = 7) breeding seasons (P = 0.54). With seasons pooled, no significant (P = 0.53) differences in range sizes were observed between Study Area I (n = 37) and Study Area II (n = 18).

The average range size pooled for all study areas, seasons, and sex and age classes was 207 ha (Table 3). The average range size for all males was 193 ha, with 211 ha for adult males and 143 ha for juvenile males (Table 3). Average range size for females was 236, with 173 ha for adult females and 276 ha for juvenile females. The

Table 2. Mean range size (ha) for LPC presented by season within years and by study areas in the Texas Panhandle from April–December 2001 and April–August 2002.

	Study Area I				Study Area II			
Year/Season	n	$\bar{x}$	Median	SE	n	$\bar{x}$	Median	SE
2001								
Breeding	16	295.1	216	62.1	8	181.1	118.5	56.0
Fall	4	261.8	283	40.4	3	171.0	177.0	30.7
Pooled	20	288.5	50.0	237	11	178.4	40.7	177
2002								
Breeding	17	167.0	134	24.8	7	115.7	108.0	23.9

average range size for Study Area I males was 218 ha and the average range size for Study Area II males was 139 ha. The average range size for Study Area I females was 262 ha and the average range size for Study Area II females was 183 ha (Table 3).

Table 3. Mean range size (ha) for LPC by sex and age classes collected at 2 study areas in the Texas Panhandle from April–December 2001 to April–August 2002.

	Study Area I				Study Area II				Combined			
Age/sex	*N*	$\bar{x}$	SE	Median	*n*	$\bar{x}$	SE	Median	*n*	$\bar{x}$	SE	Median
Adult Male	20	240	33	222	7	125	28	108	27	211	27	185
Juvenile Male	5	131	36	134	5	155	74	57	10	143	29	110
Males	25	218	29	189	12	139	33	96	37	193	23	177
Adult Female	6	174	29	155	1	168	[a]	168	7	173	24	168
Juvenile Female	6	350	144	225	5	186	59	139	11	276	83	147
Females	12	262	75	160	6	183	49	154	18	236	52	158
Total	37	233	31	185	18	154	27	127	55	207	23	173

[a]SE not calculated because of insufficient sample size.

No significant ($P > 0.05$) differences were observed for range sizes between adult and juvenile males or adult and juvenile females at either study area. Similarly, no significant differences for male ($P = 0.56$) or female ($P = 0.58$) ranges were observed between study areas. With study areas combined, no significant differences in range sizes were observed between adult and juvenile males ($P = 0.13$) or between adult and juvenile females ($P = 0.73$). Also, with study areas combined, there was no significant ($P = 0.57$) difference in range sizes between males and females.

Movements

In 2001, 33, 8, and 4 LPCs were monitored during the breeding season, fall, and winter for both study areas (Table 4). In 2002, 32 birds were monitored only during the breeding season. In 2001, sufficient data were collected to estimate 28 seasonal

Table 4. Mean movements (m) for LPC presented by season within years and by study areas in the Texas Panhandle from April–December 2001 and April–August 2002.

	Study Area I				Study Area II			
Year/season	*n*	$\bar{x}$	Median	SE	*n*	$\bar{x}$	Median	SE
2001								
Breeding	20	499.5	428	54.1	13	465.0*	337	137.0
Fall	4	630.0	640	32.6	4	583.8*	596	54.9
Winter	4	675.3	675	26.7				
Pooled	28	543.0	41	521	17	493.0	105	417
2002								
Breeding	23	434.8	403	35.8	9	355.3	360	26.5

movements (n = 20) at Study Area I and 17 movements (n = 13) at Study Area II (Table 4). In 2002, 23 breeding season movements were calculated at Study Area I and 9 at Study Area II. Individual seasonal movements varied from 54 m between locations at Study Area II for an adult male in the 2001 breeding season to 2,040 m between locations for a juvenile female at Study Area II during the 2001 breeding season.

During 2001 (Table 4), no differences (P = 0.66) were observed between average distance between locations during the breeding (n = 20) and fall (n = 4), or fall and winter (n = 4) seasons (P = 0.33) in Study Area I. No differences (P = 0.60) in average distance between locations were detected between the 2001 breeding and the 2002 breeding seasons (n = 23). At Study Area II (Table 4), the average distance between locations differed (P = 0.028) between the 2001 breeding (n = 13) and fall (n = 4) seasons, but not (P = 0.087) between the 2001 (n = 13) and 2002 (n = 9) breeding seasons. No significant differences (P = 0.57) in movements were observed between Study Area I (n = 51) and Study Area II (n = 26).

The average distance between locations for all males for both study areas was 433 m, with 454 m for adult males and 378 m for juvenile males (Table 5). The average distance between locations for females was 570 m, with 490 m for adult females and

Table 5. Mean movements (m) for LPC by sex and age classes collected at 2 study areas in the Texas Panhandle from April–December 2001 to April–August 2002.

	Study Area I				Study Area II				Combined			
Age/Sex	*N*	$\bar{x}$	SE	Median	*n*	$\bar{x}$	SE	Median	*N*	$\bar{x}$	SE	Median
Adult Male	28	502	28	521	10	317	56	340	38	454	29	428
Juvenile Male	6	355	67	374	8	395	46	364	14	378	38	374
Males	34	476	28	455	18	352	37	347	52	433	23	420
Adult Female	10	503	62	436	1	357	[a]	357	11	490	57	431
Juvenile Female	7	569	140	402	7	699	225	508	14	634	129	493
Females	17	530	66	431	8	656	200	507	25	570	76	440
Total	51	494	29	438	26	445	70	364	77	478	30	425

[a]SE not calculated because of insufficient sample size.

634 m for juvenile females (Table 5). Males at Study Area I moved an average of 476 m and males at Study Area II moved an average of 352 m. The average distance

between locations for females was 530 m at Study Area I and 656 m at Study Area II (Table 5). The average distance between locations pooled by study areas, season, sex, and age classes was 478 m (Table 5).

There was no significant ($P > 0.5$) difference in distances moved between adult and juvenile males and between adult and juvenile females within either study area (Table 5). With age classes pooled, movements were significantly ($P = 0.01$) smaller for males at Study Area I than Study Area II, but females movements were similar. With study areas pooled, there was no significant differences in distance moved between adult and juvenile males ($P = 0.15$) and between adult and juvenile females ($P = 0.71$). With study areas and age classes pooled, there was no significant ($P = 0.24$) difference between males and females. The average distance between locations pooled by study areas, season, sex, and age classes was 478 m (Table 5).

Cover Use

The average area occupied (polygon) by all LPC trapped at a given lek for both study areas was 1,508 ha and varied from 3,679 ha (n = 13 birds radio-tagged) to 152 ha (n = 1 bird radio-tagged). At the southern ranch of Study Area I, I radio-tagged 32 birds on 4 leks (n = 32 birds) and the average distance between leks was 3.5 km. Individual polygons per lek at the southern ranch of Study Area I ranged from 3,679 to 507 ha in size. All convex polygons for this site overlapped and were combined into a single polygon that encompassed 6,936 ha identified as native rangeland (100%; Table 6).

Table 6. Cover types (ha) identified for lek-associated polygons for LPC in the Texas Panhandle, 2001–2002.

Location	Total area buffered	Native rangeland	%	Non-native rangeland	%	Cropland	%	Other	%
Study Area I Ranch A	6,934	6,934	100	0	0	0	0	0	0
Study Area I Ranch B	618	618	100	0	0	0	0	0	0
Study Area I Ranch C	189	188	>99	0	0	0.9	<1	0	0
Study Area II North Lek	1,607	1,060	66	386	24	161	10	0	0
Study Area II South Lek	814	812	100	0	0	0	0	0	0

The central study site at Study Area I contained 2 leks (n = 3 birds radio-tagged) with an average distance of 2.3 km between them. Individual polygons per lek were 384 and 152 ha. Both polygons overlapped and the combined polygon area was 618 ha and located entirely in native rangeland (Table 6). The northern most study site at Study Area I contained 1 lek (n = 8 birds radio-tagged), and a convex polygon area of 189 ha (Table 6). Land cover within the polygon was 99% native rangeland and 1% cropland. The nearest known lek was 7.2 km away.

Study Area II contained 2 leks separated by a distance of 7.7 km. The northern lek (n = 9 birds radio-tagged) had a polygon area of 1,607 ha, of which 66% was on

Table 7. Cover types (ha) identified within a 2,000-m buffer of lek-associated polygons for LPC in the Texas Panhandle, 2001–2002.

Location	Total area buffered	Native rangeland	%	Non-native rangeland	%	Cropland	%	Other	%
Study Area I Ranch A	13,290	13,290	100	0	0	0	0	0	0
Study Area I Ranch B	3,766	3,766	100	0	0	0	0	0	0
Study Area I Ranch C	2,477	2,130	86	0	0	347	14	0	0
Study Area II North Lek	4,067	2,196	54	1,668	41	122	3	81	2
Study Area II South Lek	3,470	3,296	95	174	5	0	0	0	0

native rangeland, 23% non-native rangeland, and 9% cropland (Table 6). At the southern lek (n = 15 birds radio-tagged), a polygon of 814 ha was composed of 99% native rangeland, and <1% non-native rangeland, cropland, or other (Table 6).

Cover types (Table 7) within a 2,000-m buffer beyond each lek-specific convexpolygon at the southern and central study sites of Study Area I were composed of 100% native rangeland. At the northern most study site in Study Area I, 86% of the available area consisted of native rangeland and 14% cropland. At Study Area II (Table 7), available space within the buffered area around the northern lek was comprised of 54% native rangeland, 41% non-native rangeland, 3% cropland, and 2% other (i.e., roads, urban area). At the southern lek, 95% of the buffered area was native rangeland and 5% was non-native rangeland.

Invertebrates

Ten invertebrate orders were found in 53 sweep-net samples (27 in CRP, 26 in native rangeland) from a native rangeland and CRP separated <3 km apart in Wheeler County (Fig. 2). Despite the close proximity, no LPCs were observed to have used the CRP field, but were observed in the native rangeland. Orthoptera occurred in 100% of samples collected at the native rangeland site, while Hemiptera occurred in 100% of samples from the CRP site (Fig. 2). Orthoptera constituted >50% of total dry mass collected at both sites. Orthoptera comprised 98% (44.2 g) of dry mass collected at the native rangeland site and 43% (0.6 g) of dry mass at the CRP site. Total invertebrate dry mass of all orders differed between sites. A total of 45.2 g was collected at the native rangeland site, which was significantly ($P < 0.0001$) greater than 1.4 g collected at the CRP site.

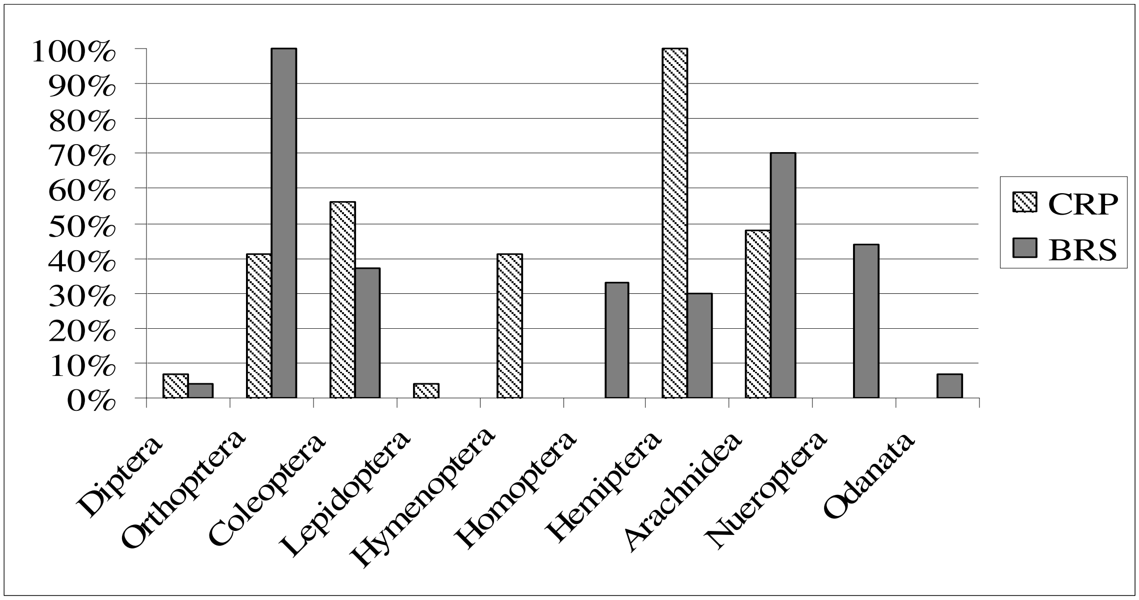

Fig. 2. Frequency of invertebrate orders collected at a Conservation Reserve Program (CRP) field and a native rangeland pasture (BRS) at Study Area II in Wheeler County, Texas, during summer (July–August) 2002.

Winter Vegetation

Winter vegetation measurements numbered 55 and 98 for Study Area I and Study Areas II, respectively. Mean visual obstruction (Table 8) differed between Study Areas I and II (3.7 and 1.9 dm, respectively). Woody species occurred on 59 and 74% of sampled plots at Study Areas I and II, but were not statistically different ($P = 0.63$).

The percent grasses, forbs, and bare ground, but not litter, differed between study areas (Table 8). Percent grass at Study Area I was more than twice that of Study Area II

(Table 8). Study Area I contained less forbs and bare ground then Study Area II. Litter between Study Area I and Study Area II was similar (Table 8).

Table 8. Winter vegetation characteristics, mean (standard error), between study areas in Hemphill and Wheeler Counties, Texas, 2001–2002.

	Study Area I (n = 55)	Study Area II (n = 98)	
Vegetation characteristics	$\bar{x}$ (SE)	$\bar{x}$ (SE)	*P*-value
Range Pole (dm)	3.70 (0.32)	1.90 (0.15)	<0.01
Grass cover (%)	44.27 (2.82)	20.33 (1.26)	<0.01
Forb cover (%)	4.18 (0.82)	12.74 (0.77)	<0.01
Litter cover (%)	15.14 (1.40)	28.86 (1.67)	0.43
Bare ground cover (%)	35.36 (2.46)	37.59 (1.37)	<0.01

DISCUSSION

No differences in LPC survival were detected between study areas within years or for combined study areas between years. Breeding season survival of LPCs for the sand sage and shinnery oak study areas was 62.7 and 70.5%, respectively. Few published data regarding seasonal or annual survival of LPCs are available. Campbell (1972) estimated annual survival at 32% for LPCs in New Mexico, Jamison (2000) reported 57% survivorship in Kansas, and Hagen et al. (2005) documented 45% annual survival for both juvenile and adult males in Kansas.

Seasonal ranges and movements during my study were similar for all seasons, except at Study Area II where movements were larger in the fall than during other seasons. Increased fall range in Study Area II probably was related to acorn production in the shinnery areas as well as grass cover; during fall, 2001, LPCs there shifted to areas that contained shinnery acorns and residual grass cover. No other differences in range size or movements were detected when sexes, ages, and seasons were pooled. Similarity in ranges and movements between study areas may have occurred because LPCs used native rangeland cover types in both areas despite considerable differences in available cover types. Had LPCs used agricultural or CRP fields, or moved to other native rangeland sites, differences in range sizes and movement distances would have been expected.

Lesser prairie chicken range size and movement distances vary by location, season, sex, and age (Sell 1979, Taylor and Guthery 1980, Giessen 1994, Jamison 2000, Jamison et al. 2002). Seasonally, ranges and movements tend to be smaller during the breeding season than in fall or early winter when some birds disperse or supplemental grain crops become available and draws flocks in (Copelin 1963, Campbell 1972, Crawford and Bolen 1976, Taylor 1978, Jamison 2000).

During my study, LPCs almost exclusively occupied native rangeland sites at both study areas. At Study Area I, >85% of area within lek-associated polygons and buffered areas was native rangelands. The smallest percentage of native rangeland within a polygon (66%) occurred at a small lek at the northern portion of Study Area II. Cover types within the buffered zone at this lek site contained a smaller portion of area classified as native rangeland (54%). This lek was located at a portion of the ranch that had been monitored by the TPWD biologists during spring lek surveys since the 1940s. Prior to the 1960s, the area contained the highest known density of LPCs in the Texas Panhandle (Jackson and DeArment 1963). Similarly, Copelin (1963), Riley et al. (1992), and Jamison (2000) noted that LPCs selected native prairie in preference to other available cover types in Oklahoma, New Mexico, and Kansas, respectively, while Crawford and Bolen (1976) estimated ≥63% native rangelands were required to maintain LPCs in the southwestern Texas panhandle.

Native rangeland constituted >95 % of the lek-associated polygon and buffered areas for the southern lek on Study Area II. Despite availability of cropland and CRP fields within a 2,000-m buffer beyond polygons at the northernmost lek, LPCs avoided these cover types. Previous studies also have shown that selection of cover types by prairie chickens were related to seasonal changes in plant-species composition and structure (Jones 1964, Riley et al. 1992, Applegate and Riley 1998).

Wu et al. (2001) hypothesized changes in land use, particularly the consolidation of croplands and loss of native rangeland patches, contributed to the decline of LPC in Wheeler County between 1940 and 1996. In contrast, LPC numbers in Hemphill County remained relatively stable because large contiguous blocks of rangeland remained. My observations of land use and interviews with residents supported this hypothesis. Landowners and residents at Study Area II described the historical importance of agriculture on the LPC population. Until the early 1970s, LPCs were routinely observed feeding in grain fields and nesting in Alfalfa fields. Over time, agricultural practices became less favorable and LPCs became increasingly confined to native rangeland habitat within the ranch boundary at Study Area II. At Study Area I, landowners and ranch managers noted the landscape remained relatively unchanged since 1940, with large areas of native rangelands intact.

During my study, cover-type analysis was limited to the winter season 2001. Although cover-use data for all seasons would have provided greater insight into annual requirements of LPCs, winter cover is key to survival and reproduction (Taylor and Guthery 1980). Winter cover, including standing grasses, carried over from the previous growing season is critical to breeding and nest success (Riley et al. 1992). Baker (1953) noticed an overall absence of prairie chickens during spring months in areas where insufficient winter interspersion of food and cover occurred. Winter cover can be particularly important in periods of drought when cover, food, and moisture from leafy vegetation are limited (Applegate and Riley 1998).

A drought was in place during both years of my study. From 2000 through 2002, the mean rainfall amount was 43.9 cm or 27% less than the 30 year average (National Climatic Data Center 2002). Mean OV was greater at Study Area I than Study Area II during 2001. Woody species are an important component of LPC cover (Taylor 1978, Taylor and Guthery 1980). Lower OV at Study Area II was attributed, in part, to leaf senescence of shinnery oak as compared to sand sage in Study Area I which retained its leaves. Unfortunately, OV measurements could not distinguish coverage provided by woody versus grass species. Vegetative samples, however, did provide insight into woody stem occurrence and percent coverage of herbaceous species. Woody stems occurred more often at Study Area I than Study Area II. Further, grass coverage at Study Area I was twice that seen in Study Area II.

Residual cover provided by standing grasses is important in shinnery oak rangelands, particularly in the early spring prior to green up. In the southwestern Texas Panhandle, Taylor (1978) noted that LPCs shifted locations from shinnery oak habitats to areas with greater amounts of cover comprised of little bluestem and sand sage. Similarly, Jamison (2000) noted LPCs in Kansas preferred sand sage rangelands interspersed with native grasses as compared to other cover types such as agricultural fields, CRP fields, or shortgrasss, mixed-grass, and tallgrass rangeland types.

I found that LPCs selected areas with stands of little bluestem and avoided areas of woody species coupled with short overgrazed grasses. At Study Area II, cattle destroyed at least 1 nest when grass became limited and LPCs increasingly competed with cattle for limited grass patches. Moreover, palatability of grasses for cattle is greatest during spring and early summer months when LPCs are nesting. Negative impacts of heavy grazing on prairie grouse populations are well documented (Hamerstrom et al. 1957, Jackson and DeArment 1963, Jones 1963, Crawford and Bolen 1976, Litton et al. 1994). Effectively, grazing results in the alteration of cover structure, and as grazing pressure increases, more broad scale impacts on structural integrity result. Cannon and Knopf (1981) noted LPC preferred mixed-grass and tallgrass areas within shinnery oak rangelands. They also noted that LPC abundance in shinnery sites was positively correlated with percent grassland and negatively correlated with percent shrubland, while the reverse was true in sand sage rangelands.

The structural quality of cover also may have had a direct effect on LPC abundance and cover selection within the 2 rangeland types I studied. The difference in LPC abundance between the 2 rangeland types was most likely related in the long-term to land use and in the near-term to range condition. Range condition at Study Area I (sand sage rangeland) as fair to good, but was poor at Study Area II (shinnery oak rangeland). Thus, I maintain that differences in range condition resulted primarily from the intense grazing pressure caused by a non-rotational stocking regime on Study Area II.

Previous research has shown that CRP fields typically do not attract or retain LPCs even though they can provide suitable nesting cover (Sullivan et al. 2000). In Wheeler County, CRP fields were observed to provide neither adequate nesting nor brood-rearing cover. No LPCs were observed nesting or otherwise using CRP fields despite their close proximity (<2 km) to the study area. These CRP fields were tall, dense stands of nearly impenetrable weeping lovegrass. Additionally, little forb or invertebrate production occurred within the CRP. Invertebrates are critical to LPC survival and reproduction particularly during summer months (Baker 1953, Jamison 2000). Invertebrates, particularly the order Orthoptera, are important to prairie chickens during summer and fall (Jones 1964), and essential to the growth and development of chicks (Griffon et al. 1997).

I found invertebrate production was 32 times greater at a native rangeland site than a CRP site in Wheeler County. This undoubtedly occurred because the native rangeland contained a diversity of forb species, while the CRP site was essentially a monoculture of weeping lovegrass. Jamison (2000) also noted the strongest predictor of invertebrate abundance was forb production for his study area in Kansas. Not all CRP fields, however, lack invertebrate productivity. Incorporating as little as (227 g/ha) legume seeds, such as alfalfa, significantly increased invertebrate productivity of CRP fields (Bidwell undated).

Many gallinaceous birds, including lesser prairie chickens, have been relegated to small habitat fragments (Silvy et al. 2004). As a result, LPCs have become more prone to predation and genetic isolation because large areas of usable space (Guthery 1997) have declined over the decades (Silvy et al. 2004). For my study, more usable space as defined by native rangeland was available at Study Area I than Study Area II. However, I do not expect LPC numbers to increase at either study area or expand their range in the short term because occupied ranges are constrained when compared to previous distributions of LPC in the Rolling Plains (Wu et al. 2001).

Lines drawn around all perimeter locations of LPCs encompassed a total area of 14,661 and 5,280 ha on Study Areas I and II, where LPC numbers are stable and declining, respectively. Thus it is likely that $\geq$15,000 ha is a minimum area required for a viable LPC population in the Rolling Plains of Texas. The relevance of lek-specific range and movement data may need to be considered within a context of scale and time sufficient to assist in landscape planning. Suggested minimum areas required to support LPC populations have ranged from ≥1,024 ha (Copelin 1963) to >7,200 ha (Taylor and Guthery 1980). An important concept of minimum area is the idea of scale, both temporally and spatially. Woodward et al (2001) noted LPC declined more in areas where greater landscapes changes had occurred over time. Fuhlendorf et al. (2002) noted landscape changes over time had the greatest explanation of trends for declining and stable populations.

SUMMARY AND CONCLUSIONS

Ranges and movements of LPC were similar between study areas with all seasons, sexes, and age classes combined except between the spring and fall of 2001 at Study Area II. The similarity in ranges and movements may provide insight into minimum area requirements for LPC that occupy native rangelands. Despite differences between study areas at a landscape scale, data from my study indicated $\geq$15,000 ha are required to sustain a complex of actively breeding leks in the Rolling Plains of Texas of the Texas Panhandle.

I also found that:

1. LPC selected native rangelands in preference to all other available cover types.
2. Survival was similar between study areas despite differences in population trends.
3. There was twice as much grass and less forbs and bare ground at the sand sage study site than at the shinnery oak study site.
4. Invertebrate production was 32 times greater in native rangeland than in CRP.

Management Recommendations

1. Management efforts should aim at preserving existing large blocks of native rangelands. Based on my study, $\geq$15,000 ha are required to sustain a complex of actively breeding leks in the Rolling Plains of Texas. Thus, efforts should be made to stabilize existing LPC populations by providing sufficient useable space through time (Guthery 1997, Silvy et al. 2004) prior to attempting to establish additional independent populations.

2. Habitat management should focus on creating new habitat concentrically away from existing large blocks of occupied habitat as opposed to developing small patches of habitat elsewhere. Small patches may fail to be selected or provide contain sufficient area for annual habitat requirements (Guthery 1997, Silvy et al. 2004).
3. Conservative grazing regimes should be promoted, particularly in deciduous shinnery oak rangelands during winter months. Potential nesting and brood rearing habitat should be identified and protected with fencing during the non-growing seasons to preserve standing grass cover.
4. Considering the importance of invertebrates to gallinaceous species, including LPCs, further research should examine methods to increase invertebrate production in CRP fields. A low cost method might include the addition of lightly disked strips into monoculture stands of grasses to promote annual forbs.
5. Unbiased and precise survey methods for LPC abundance need to be developed and used to monitor long-term success or failure of management strategies designed to improve LPC habitats and abundance in an adaptive fashion.

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